

# Microtox™ and *Ceriodaphnia dubia* toxicity of BKME with powdered activated carbon treatment™

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## Abstract

This paper compares treatment of bleached kraft pulp mill effluent (BKME) using activated sludge vs. PACT™, with respect to removal of toxicity as measured using two different assays: Microtox™ and *Ceriodaphnia dubia*. Both activated sludge and PACT™ treatment processes were operated over a range of solids and hydraulic retention times using BKME. Various doses of powdered activated carbon were applied in the PACT™ process.

Activated sludge treatment is sufficient to remove nearly all detectable Microtox™ toxicity for bleached kraft pulp mill effluent with initial low to moderate toxicity. Based on the Microtox™ toxicity assay, PACT™ was found to slightly improve the toxicity level of highly toxic bleached kraft pulp mill effluent.

The chronic *Ceriodaphnia dubia* toxicity assay was more sensitive than the Microtox™ assay in determining toxicity. Significant residual chronic toxicity towards *Ceriodaphnia dubia* remained in all bleached kraft pulp mill effluents, irrespective of the treatment process. Both activated sludge and PACT™ remove toxicity, but PACT™ effluents are more toxic. Powdered activated carbon alone shows chronic toxicity towards *Ceriodaphnia dubia*, probably due to physical ingestion of powdered activated carbon particles.

## Introduction

Effluents from the pulp and paper industry are complex wastes that are difficult to treat. Toxicity and organic loading of this waste pose a hazard to aquatic organisms. Currently secondary treatment using the aerobic activated sludge process is required for pulp mill wastewater. The powdered activated carbon treatment™ (PACT™) process, is a modification of the activated sludge process in which powdered activated carbon (PAC) is added to the mixed liquor. Biomass grows directly on the carbon particles, thus the mixed liquor suspended solids (MLSS) is a combined mass of carbon and biomass.

PACT™ has been shown to improve the treatment of a variety of toxic wastewaters and a number of advantages of PACT™ over standard AS treatment has been cited (Deitrich et al., 1988; Hutton, 1990; Lankford and Eckenfelder, 1990; Meidl, 1990). These include:

- Improved removal of chemical and biochemical oxygen demand (COD and BOD respectively).
- Stability of operation with variability in influent concentration and composition.
- Enhanced removal of toxic substances and priority pollutants.
- Effective colour removal.
- Improved solids settling.
- Suppressed stripping of volatile organics.

Only one example of applying PACT™ to the treatment of pulp and paper industry wastewater has been reported (Verrault and Dupuy, 1992). However, the particular application was paper making rather than wood pulping. The study reported on the use of a 56 m<sup>3</sup> PACT™ to treat spent cooking liquors from cotton fibre and

cellulose fibre pulping at a fine paper mill (18 000 to 25 000 mgCOD/l, and 9 000 to 10 000 mgBOD/l) with a PAC dosage of 1.21 g/l. The authors reported good treatment, 90 to 92% removal of COD and >98% removal of BOD. However, no comparison of PACT™ and activated sludge (AS) was made and the study did not concern itself with toxicity removal. The objective of this paper is to compare the performance of the activated sludge process and the PACT™ process in terms of toxicity removal as measured by Microtox™ and *Ceriodaphnia* chronic toxicity test assays.

## Microtox™ and *Ceriodaphnia dubia* toxicity assays

Microtox™ is a patented toxicity assay (Microbics Corporation Carlsbad, CA) that uses a light-emitting marine bacterium, *Photobacterium phosphoreum* and measures the decrease in light output in response to a 5 or 15 min exposure to toxicant. Toxicity of a sample is generally reported as an *effective concentration 50%* (EC<sub>50</sub>), meaning the concentration of test sample at which there is a 50% reduction in bacterial light production. Values may also be reported as EC<sub>10</sub> or EC<sub>20</sub>, the concentrations at which respectively 10% and 20% reductions in light output are observed. Reported EC values are inversely proportional to toxicity, i.e. the lower the EC value, the more toxic the sample. The main advantage of the Microtox™ assay is its speed and convenience as it can be conducted in less than 1 h. Its disadvantage is its relative insensitivity compared to other bioassays.

A number of studies have investigated the use of Microtox™ for evaluating pulp and paper wastewater toxicity (Table 1). Many of these tried to correlate Microtox™ with standard bioassays (i.e., fish and algae) in the hope that the latter more expensive and cumbersome tests could be replaced. Blaise et al. (1987) compared Microtox™ to algal and fish toxicity tests and reported that biological treatment of chemithermomechanical pulp (CTMP) effluent reduced Microtox™ toxicity from about 5% to >100%. Very low toxicity remained with respect to trout, and moderate toxicity with respect to algae. Fish were generally the least sensi-

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